Limb Salvage for Malignant Bone Tumors in Young Children

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SUMMARY

From March 1984 to April 1991, the Orthopaedics Department of the Clínica Universitaria de Navarra treated 47 cases of malignant bone tumors in young children by limb-salvage surgery. Mean follow-up time was 4.4 years. The histologic diagnoses were osteosarcoma (33 cases) and Ewing's sarcoma (14 cases). All patients were treated following the Cancer Protocol of the Clínica Universitaria de Navarra. We used allograft reconstruction in 26 patients, autograft reconstruction in seven, and nonbiologic material in seven other patients. Thirty-six of these patients are alive currently; 11 have died. The overall survival rate was 76.6%. Three patients suffered local recurrences, and seven developed metastatic disease. The most significant complications were infection in four cases, and osteosynthesis anchorage detachment in eight cases. We believe that with recent medical, surgical, and rehabilitative advances, limb-salvage surgery has surpassed amputation as the primary treatment for malignant bone tumors in young children.

KEY WORDS

Allograft; Bone graft; Ewing's sarcoma; Osteosarcoma.

INTRODUCTION

Primary malignant bone tumors occur in children (43). In about 75% of these patients, the lesions are located around the growth plate (30). Historically, these tumors have been treated by amputation (6). Only recently have more conservative procedures been practiced. The introduction of the new methods, namely diagnosis by image (25,28,31,35,45,52, 56) and use of preoperative chemotherapy (2,3,33, 39,42,44,47-49), contributed to indications for limb salvage. An increasing interest in limb-reconstruction techniques after resections has thus developed (1,4,8,9-12,14,15,17-22,24,26,27,29,32,3638,40,41,46,51).

Lesions occur most commonly in the lower limbs. The orthopedist must consider the eventual functional status resulting from the secondary deformity, which is predicted by the amount of removed physeal cartilage, when selecting a method of reconstruction. Our aim was to evaluate survival, functional results, and complications in patients treated with limb salvage instead of amputation.

MATERIALS AND METHODS

Patients treated for high-grade bone sarcomas from March 1984 to April 1991 were analyzed. Only patients who had a follow-up of ≥1 year were included in the study. Of the 47 patients, 21 were boys and 26 were girls. Average age was 11.6 years (range, 4-15 years). Histologic diagnosis was osteosarcoma in 33 cases and Ewing's sarcoma in 14. The anatomic cites of the lesions included 26 in the femur (three proximal, 10 mid-diaphyseal, 13 distal), 15 in the tibia (11 proximal, one mid-diaphyseal, 3 distal), three in the humerus, two in the fibula, and one in the radius. Clinical data are given in Table 1.

All the patients were treated following the Cancer Protocol of the Clínica Universitaria de Navarra (7) (Table 2). (Surgical treatments are listed in Table 3.) The length of resection was 16.3 cm (range 10-34 cm).

RESULTS

Thirty-two of the 47 observed patients (68%) were alive and disease free after an average follow-up period of 53 months (minimum 12 months; maximum 96 months). Another 8.5% were alive with disease (6.4% with metastases and 2.1% with local recurrence). The remaining 23.4% died from metastases or local recurrence (14.9%), aplasia (6.4%), and leukemia (2.1%).

Functional results were obtained using the classification adopted from the MSTS (23). Four cases (8.5%) involved the shoulder girdle or the upper extremity, and 43 (91.5%) involved the pelvic girdle or lower extremity. In proximal humerus resections, functional results were good in 50% of the cases (Fig. 1). In proximal femoral resections, reconstruction was accomplished with prostheses in all cases (Fig. 2); 66% of the cases had good results. One patient underwent Chiari osteotomy because he presented with a subluxans prosthesis. In the femoral and tibial diaphyseal resections, the results were excellent or good in 65% of the cases (Figs. 3-5).

In knee resections, 15 were treated with a GSB prosthesis (Fig. 6), and three received an osteoarticular allograft. Seventy percent of those treated with prosthesis had excellent or good functional results. Patients treated with osteoarticular allograft had poor results.

The most significant complications were infection in four cases (8.5%) and osteosynthesis anchorage detachment in eight cases (17%) (Fig. 7). The deep infections were treated by removal of the infected allograft. Limb length was maintained either by an antibiotic-impregnated polymethylmethacrylate spacer (Gentamicin-PMMA beads) or by bone cement with gentamicin (13) and external fixation. Antibiotics were then administered for 1-3 months; a new allograft was implanted in two patients. Gram-positive organisms were the most common cause of infection. The delayed unions were treated by new reosteosynthesis plus autograft bone. Seven patients presented with limb-length discrepancies. These length inequalities resulted in growth recurrence in these patients. They were treated by limb lengthening (16) (Fig. 8).

DISCUSSION

Over the past several decades, there has been increased enthusiasm for limb-salvage surgery as a result of the improvements in the effectiveness of chemotherapy, better tumor imaging, and technical advancements in reconstructive surgery. Recent evidence suggests that excellent local tumor control can be achieved with preservation of function. Harris et al. (32) studied limb-salvage patients and compared them functionally with patients who had undergone amputation. Their study found comparable functional results between the two groups, but better emotional acceptance among limb-salvage patients. The local recurrence rate for limb salvage is similar to that for above-the-knee amputations (50). Survival rates are also comparable (50).

Limb salvage is actually two separate operative procedures: the first involves tumor excision; its adequacy can be judged simply by the rate of local recurrence. The second procedure is reconstruction. There have been many recent reports in which various forms of reconstruction after limb salvage were reviewed (1,4,8,9-12,14,15,17-22,24,26,27,29, 32,36-38,40,41,51). These procedures include prosthetic replacement, osteoarticular allograft arthroplasty, allograft—prosthetic composite arthroplasty, and arthrodesis. These reconstructive alternatives are currently being vetted for durability, function, and morbidity. We believe that the type of reconstruction used should be based on the individual patient's age, size, functional demands, and desires; the surgeon's experience should also be a factor.

Resections requiring reconstruction can be subdivided into two major categories: diaphyseal resections and articular resections. We think that bone intercalary grafts are the proper treatment for diaphyseal resections. In these cases, allografts represent the ideal solution. We used the physeal distraction [Cañadell technique (8)] in 12 of our patients. At present, it is not completely clear what role chemotherapy plays with respect to the incorporation of bone grafts. There are various reports in the literature that give opposing viewpoints on the inhibition of osteogenesis from cytotoxic medications. These medications only slightly reduce the recipient's osteogenesis and the union of the graft (27).

Articular resections represent the most complex reconstruction problem in oncologic surgery. Three forms of arthroplasty are used, namely prosthetic, osteoarticular allograft, and allograft—prosthetic composite arthroplasty. Prosthetic arthroplasty replaces bone and joint with a metallic implant along with a polyethylene articulation. The constraint of the device is determined by the amount of soft tissue resection, and can range from resurfacing arthroplasty to hinge prosthesis. The advantage of prosthetic arthroplasty after tumor excision is ease of insertion and good short-term functional results. Its durability is uncertain, however.

Osteoarticular allograft arthroplasty is a purely biologic solution to the replacement of bone and joint after en bloc tumor excision. This procedure replaces bone stock, and soft-tissue attachment to the allograft is possible. The drawbacks with this technique include articular degeneration, fracture, nonunion, and unstable joints.

The newest reconstructive procedure to receive attention is the combination of a prosthetic arthroplasty with allograft bone replacement (9,10,12). This type of arthroplasty may diminish some of the previously mentioned problems. It is a technique that combines an allograft with an off-the-shelf arthroplasty, thus eliminating the need for custom prosthetic manufacturing and articular degeneration, and allowing for soft-tissue attachment. Cara et al. (10) and Johnson and Mankin (34) described this technique as well as its indications, and, in our own experience, prosthetic arthroplasty with allograft has yielded a lower incidence of complication and better functional results than osteoarticular allograft arthroplasty.

Arthrodeses are particularly indicated in surgery of the lower extremity. We use this technique principally in tumors localized in the distal tibia. Of considerable importance is the asymmetry at the end of growth, which might be severe enough to eliminate most of the advantages of preserving joint motion. This problem is obviously more serious in lower-extremity reconstruction. In the upper limb, severe asymmetry of up to 8-10 cm can be tolerated. In the lower extremity, several procedures have been described that show potential application in children.

The first of these procedures is the Van Ness rotation plasty for sarcomas of the extremity. This procedure preserves the ankle and rotates the limb 180°, placing the ankle at the anatomic knee-joint level. The limb can be fitted as a below-the-knee amputation with greatly improved function (5). Another technique is the use of an expandable prosthesis for children who have significant growth potential. These devices are implanted after en bloc resection, and allow for further lengthening of the device as the child grows (36). Long-term durability of this device remains suspect.

Our experience with bone lengthening in children leads us to believe that this technique is the most physiological reconstruction; sometimes, a contra-lateral epiphysiodesis is performed to maintain symmetry at the end of growth.

All these techniques continue to have a high complication rate. The significant and sometimes unavoidable complications include mechanical failure of the implant, pseudarthrosis at the bone site, and infection. Infection is a particularly troublesome complication with allografts (13). The infection rate appears to be relatively low and comparable to other reconstructive procedures. Tomford et al. (54,55) reviewed their experience with allografts for tumor reconstruction and found a relatively low incidence of infection, and none that could be attributed to graft contamination during procurement. In our series, the incidente was 8.5%, which was similar to that found in other studies (19,41,53,55).

The refinement of limb-salvage techniques has opened a new chapter in oncologic surgery of the musculoskeletal system, namely the ability to reconstruct the limb after surgical failures.

REFERENCES

1. Alho A, Karaharju E0, Korkala O, Lassonen EM, Holmstrom T, Muller C. Allogeneic grafts for bone tumor. Acta Orthop Scand 1989;60:143-53.
2. Bacci G, Picci P, Gitelis S, Borghi A, Campanacci M. The treatment of localized Ewing's sarcoma. The experience at the Istituto Ortopedico Rizzoli in 163 cases treated with and without adjuvant chemotherapy. Cancer 1982;49:1561-70.
3. Bacci G, Toni A, Avella M. Long-term results in 144 localized Ewing's sarcoma patients treated with combined therapy. Cancer 1989;63:1477-86.
4. Brown KLB. Limb reconstruction with vascularized fibular grafts after bone tumor resection. Clin Orthop 1991;262:6473.
5. Cammisa FP, Glasser DB, Otis JC, Kroll MA, Lane JM, Healey JH. The Van Ness tibial rotationplasty: a functionally viable reconstructive procedure in children who have a tumor of the distal end of the femur. J Bone Joint Surg [Am] 1990;72:1541-7.
6. Campanacci M, Bacci G, Bertoni F, Picci P, Minutillo A, Franceschi C. The treatment of osteosarcoma of the extremities: twenty year's experience at the Istituto Ortopedico Rizzoli. Cancer 1981;48:1569-86.
7. Cañadell J. Protocolos terapéuticos del cáncer de la Clínica Universitaria de Navarra. Departamento de Cirugía Ortopédica y Traumatología. Pamplona: EUNSA, 1984:313-25.
8. Cañadell J, Forriol F, Cara JA. New technique in oncologic surgery: physeal distraction. J Bone Joint Surg [Br] (in press).
9. Cara JA, Amillo S. Prótesis de resección de rodilla en la cirugía reconstructiva tumoral. Rev Ortop Traum 1992;36: 39-42.
10. Cara JA, Amillo S, Cañadell J. La prótesis de resección de rodilla en la cirugía reconstructiva tumoral: Estudio comparativo entre el uso del aloinjerto y espaciador plástico. Rev Med Univ Navarra 1991;36:69-75.
11. Cara JA, Amillo S, Cañadell J. Injertos óseos en cirugía tumoral maligna: autoinjerto versus aloinjerto. Rev Soc Traum Ortop 1992;12:117-24.
12. Cara JA, Amillo S, Ganoza C. Use of knee endoprostheses in bone tumours. In: Brown KLB, ed. Complications of limb salvage. Prevention, management and outcome. Montreal: ISOLS, 1991:117-21.
13. Cara JA, Cañadell J, Lacleriga A. Infection in grafting procedures. In: Brown KLB, ed. Complications of limb salvage. Prevention, management and outcome. Montreal: ISOLS, 1991:41-4.
14. Cara JA, Gil-Albarova J, Amillo S, Cañadell J. Utilización de aloinjertos masivos en la cirugía reconstructiva tumoral. Rev Ortop Traum 1992;36:8-12.
15. Cara JA, Gil-Albarova J, Amillo S, Cañadell J. Bone allograft after segmental resection of bone tumours. In: Lindholm ST, ed. New trends in bone grafting. Tampere: University of Tampere Press, 1992:191-9.

16. Cara JA, Gil-Albarova J, Cañadell J. Correction of late limb length discrepancies after treatment of bone tumours. In: Brown KLB, ed. Complications of limb salvage. Prevention, management and outcome. Montreal: ISOLS, 1991: 533-8.
17. Cara JA, Lacléríga AF. Intercalary bone allograft for reconstruction after tumor excision. Acta Orthop Scand (in press).
18. Cara JA, Lacléríga AF, San Julian M, Cañadell J. Tratamiento de los tumores metafiso-epifisarios malignos de extremidad inferior con prótesis. Rey Esp Cir Osteoart 1992; 27:189-97.
19. Delépine G, Delépine N. Résultats préliminares de 79 allogreffes osseuses massives dans le traitement conservateur des tumeurs malignes de l'adulte et de l'enfant. Int Orthop (SICOT) 1988;12:21-9.
20. Dick H, Malinin T, Mnaymneh W. Massive allograft implantation following radical resection of high-grade tumours requiring neoadjuvant chemotherapy treatment. Clin Orthop 1985;197:88-94.
21. Dubousset J, Missenard G, Genin J. Traitment chirurgical conservateur des sarcomas ostéogeniques des membres. Techniques et résultats fonctionnels. Rey Chir Orthop 1985; 71:435.
22. Eckardt JJ, Eilber FR, Rosen G, Mirra JM, Dorey FJ, Ward WG, Kabo JM. Endoprosthetic replacement for stage IIB osteosarcoma. Clin Orthop 1991;270:202-13.
23. Enneking WF. A system for the functional evaluation of the surgical management of musculoskeletal tumors. In: Enneking WF, ed. Limb salvage in musculoskeletal oncology. New York: Churchill Livingstone, 1987:5-16.
24. Enneking WF, Eady JL, Burchardt H. Autogenous cortical bone grafts in the reconstruction of the segmental skeletal defects. J Bone Joint Surg [Am] 1980;62:1039-58.
25. Exner GU, Von Hochstetter AR, Augustiny N, Von Schulthess G. Magnetic resonance imaging in malignant bone tumour. Int Orthop 1990;14:49-56.
26. Fernandez JM, Cabanas MI, Navarrete FJ, Marco F, Noriega M, De Pedro JA, Leon C, Ortega L, Lopez-Duran, L. Homoinjerto masivo diafisario en la reconstrucción esquelética tras exéresis tumoral. A propósito de un caso. Rev Ortop Traum 1989;33:109-11.
27. Finn HA, Simon MA. Limb-salvage surgery in the treatment of osteosarcoma in skeletally immature individuals. Clin Orthop 1991;262:108-18.
28. Frank JA, Ling A, Patronas NJ. Detection of malignant bone tumors: MR imaging vs scintigraphy. AJR 1990;155:1043-8.
29. Gebhardt MC, Flugstad DI, Springfield DS, Mankin HJ. The use of bone allografts for limb salvage in high-grade extremity osteosarcoma. Clin Orthop 1991;270:181-96.
30. Gitalis S. Limb salvage for appendicular tumors. Curr Opin Orthop 1991;2:811-6.
31. Golfieri R, Baddeley H, Pringle JS, Souhami R. The role of the STIR sequence in magnetic resonance imaging examination of bone tumours. Br J Radiol 1990;63:251-6.
32. Harris IE, Leff AR, Gitelis S, Simon MA. A comparison of function and walking efficiency in patients with aggressive tumors at the knee treated by above-the-knee amputation, knee arthrodesis or knee arthroplasty. J Bone Joint Surg [Am] 1990;72:1477-83.

33. Hudson M, Jaffe N, Ayala A. Pediatric osteosarcoma: therapeutic strategies, results, and prognostic factors derived from a 10-year experience. J Clin Oncol 1990;8:1988-97.
34. Johnson ME, Mankin HJ. Reconstruction after resections of tumors involving the proximal femur. Orthop Clin North Am 1991;22:87-103.
35. Kattapuram SV. Imaging of musculoskeletal tumors. Curr Opin Orthop 1991;2:781-7.
36. Kenan S, Bloom N, Lewis MM. Limb-sparing surgery in skeletally immature patients with osteosarcoma. The use of an expansible prosthesis. Clin Orthop 1991;270:223-30.
37. Kohler R, Corge F, Brumafmentigny M, Moyer D, Patricot L. Massive bone allograft in children. Clin Orthop 1990;14: 249-54.
38. Kotz R. Possibilities and limitations of limb preserving therapy for bone tumors today. J Cancer Res Clin Oncol 1983; 106:68-76.
39. Link MP, Goorin AM, Miser AW. The effect of adjuvant chemotherapy on relapse-free survival in patients with osteosarcoma of the extremity. N Engl J Med 1986;314: 1600-6.
40. Majo J, Doncel A, Lopez Pousa A, Pardo N, Vancells M, Garcia J, Miralles A. Resección en bloque y homoinjertos criopreservados de cadaver con quimioterapia pre y postoperatoria en tumores óseos malignos de extremidades. Rev Ortop Traum 1990;34:532-7.
41. Mankin HJ, Doppelt SH, Sullivan TR, Tomford WW. Osteoarticular and intercalary allograft transplantation in the management of malignant tumors of bone. Cancer 1982;50: 613-30.
42. McDonald Di, Capanna R, Gherlinzoni. Influence of chemotherapy on perioperative complications in limb salvage surgery for bone tumors. Cancer 1990;65:1509-16.
43. Mercuri M, Capanna R, Manfrini M. The management of malignant bone tumors in children and adolescente. Clin Orthop 1991;264:156-68.
44. Miser JS, Kinsella TJ, Triche TJ. Preliminary results of treatment of Ewing's sarcoma of bone in children and young adults: six months of intensive combined modality therapy without maintenance. J Clin Oncol 1988;6:484-90.
45. Murphy WA. Imaging bone tumors in the 1990s. Cancer 1991;67:1169-76.
46. Poitout D, Novakovitch G. Utilisation des allogreffes en oncologie et en traumatologie. Int Orthop (SICOT) 1987;11: 169-73.
47. Prat CB, Champion JE, Fleming ID. Adjuvant chemotherapy for osteosarcoma of the extremity. Long-term results of two consecutive protocol studies. Cancer 1990;65:439-45.
48. Rosen G, Caparros B, Nirenberg A. Ewing's sarcoma. Ten-year experience with adjuvant chemotherapy. Cancer 1981; 47:2204-13.
49. Rosen G, Marcove RC, Caparros B, Nirenberg A, Kosloff C, Huvos AG. Primary osteogenic sarcoma: the rationale for preoperative chemotherapy and delayed surgery. Cancer 1979;43:2163-78.
50. Simon MA, Aschliman MA, Thomas N, Mankin HJ. Limbsalvage treatment versus amputation for osteosarcoma of the distal end of the femur. J Bone Joint Surg [Am] 1986;69: 1331-7.
51. Springfield DS. Introduction to limb-salvage surgery for sarcomas. Orthop Clin North Am 1991;22:1-5.
52. Sundaram M, McLeod RA. MR imaging of tumor and tumorlike lesions of bone and soft tissue. AJR 1990;155:81724.

53. Tomeno B, Istria R, Merle D'Aubigne R. La résection arthrodése du genou pour tumeur. Rey Chir Orthop 1978;64: 323-32.
54. Tomford WW, Starkweather RS, Goldman MH. A study of the clinical incidence of infection in the use of banked allograft bone. J Bone Joint Surg [Am] 1981;63:244.
55. Tomford WW, Thongphasuk J, Mankin JH, Feraro MJ. Frozen musculoskeletal allografts: a study of the clinical incidence and causes of infection associated with their use. J Bone Joint Surg [Am] 1990;72:1137-43.
56. Vander Griend RA, Enneking WF. Radiologic imaging techniques in the diagnosis and treatment of osteogenic sarcoma. Semin Orthop 1988;3:59-62.

Table 1. Clinical data

Case	Age	Sex	Location	Histology	Stage	Treatment	Survival	Complications
1	14	F	Femur	Osteosarcoma	IIB	KP + nBM	Dead	Toxicity
2	13	M	Femur	Osteosarcoma	IIB	KP + nBM	Free	—
3	14	M	Femur	Ewing	III	HP	Dead	—
4	10	F	Femur	Osteosarcoma	III	KP + nBM	Dead	—
5	7	M	Femur	Osteosarcoma	IIB	Int Allo	Free	Bone length
6	15	M	Femur	Osteosarcoma	IIB	KP + nBM	Free	Replacement
7	13	M	Tibia	Ewing	IIB	KP + nBM	Dead	Nerve Palse
8	15	F	Femur	Osteosarcoma	IIB	Int Auto	Free	—
9	13	F	Femur	Osteosarcoma	IIB	Int Auto	Free	Bone length
10	4	M	Fibula	Ewing	IIB	Int Auto	Free	—
11	14	M	Femur	Osteosarcoma	IIB	Int Auto	Free	Delay Ost
12	14	F	Femur	Osteosarcoma	IIB	KP + Allo	Free	Delay Ost
13	8	F	Tibia	Ewing	IIB	Int Auto	Free	Bone length
14	12	F	Tibia	Osteosarcoma	IIB	KP + nBM	Dead	—
15	11	M	Tibia	Ewing	IIB	Int Auto	Free	Delay Ost
16	11	M	Humerus	Ewing	IIB	Int Allo	Free	—
17	10	F	Tibia	Osteosarcoma	IIB	Int Allo	Disease	Local recurrence
18	10	F	Femur	Osteosarcoma	IIB	Int Allo	Free	—
19	13	F	Tibia	Osteosarcoma	IIB	KP + nBM	Free	—
20	13	M	Femur	Ewing	IIB	Int Allo	Dead	Toxicity
21	9	F	Tibia	Ewing	IIB	Int Allo	Free	—
22	15	F	Tibia	Osteosarcoma	IIB	KP + Allo	Free	—
23	15	F	Femur	Osteosarcoma	III	Ost Allo	Disease	—
24	13	F	Femur	Osteosarcoma	IIB	KP + Allo	Free	—
25	13	F	Femur	Osteosarcoma	IIB	Int Allo	Free	—
26	8	M	Humerus	Osteosarcoma	IIB	SP	Dead	—
27	7	F	Femur	Osteosarcoma	IIB	HP	Disease	Bone length
28	14	F	Humerus	Osteosarcoma	IIB	Ost Allo	Free	—
29	13	M	Fibula	Ewing	IIB	Resection	Free	—
30	14	F	Tibia	Osteosarcoma	IIB	KP + Allo	Free	Delay Ost
31	10	M	Femur	Osteosarcoma	III	Ost Allo	Free	Bone length
32	15	F	Femur	Osteosarcoma	IIB	Int Allo	Disease	Delay Ost
33	9	M	Femur	Osteosarcoma	IIB	Ost Allo	Free	Infection
								Bone length
34	8	M	Femur	Ewing	IIB	HP	Free	Bone length
35	15	M	Femur	Osteosarcoma	IIB	Int Allo	Free	Infection
36	9	F	Femur	Osteosarcoma	IIB	Int Allo	Dead	Leukemia
37	9	F	Radio	Ewing	III	Resection	Dead	—
38	11	F	Femur	Osteosarcoma	IIB	Int Allo	Free	—
39	14	F	Tibia	Osteosarcoma	IIB	KP + Allo	Dead	Infection
40	14	F	Tibia	Osteosarcoma	IIB	Int Allo	Free	—
41	11	M	Tibia	Ewing	IIB	KP + Allo	Free	Infection
42	11	M	Tibia	Osteosarcoma	IIB	Int Allo	Free	Delay Ost
43	13	F	Tibia	Ewing	IIB	KP + Allo	Dead	Toxicity
44	15	F	Tibia	Osteosarcoma	IIB	KP + Allo	Free	—
45	14	M	Femur	Osteosarcoma	IIB	Int Allo	Free	Delay Ost
46	15	M	Femur	Osteosarcoma	IIB	Int Allo	Free	Delay Ost
47	10	M	Femur	Ewing	IIB	HP	Free	—

KP, Knee prosthesis; HP, hip prosthesis; SP, Shoulder prosthesis; nBM, nonbiologic material; Allo, allograft; Auto, autograft; Int, intercalar; Ost, osteoarticular.

Table 2. Protocol used in treatment

Osteosarcoma	
	Neoadjuvant chemotherapy (i.a. + i.v.)
	Surgery + IOR
	Postoperative chemotherapy (i.v.)
Ewing's sarcoma	
	Preoperative chemotherapy (i.v.) + Radiotherapy
	Surgery + IOR
	Postoperative chemotherapy (i.v.)

i.a., intraarterial; i.v., intravenous; IOR, intraoperative radiotherapy.

Table 3. Surgical treatment according to site

Treatment	**No. of cases**
Prosthesis	
Hip	4
Knee	
Allograft	8
Nonbiologic material	7
Intercalary graft	
Allograft	12
Autograft	7
Arthrodesis	
Allograft	2
Osteoarticular graft	
Allograft	2
Resection	2

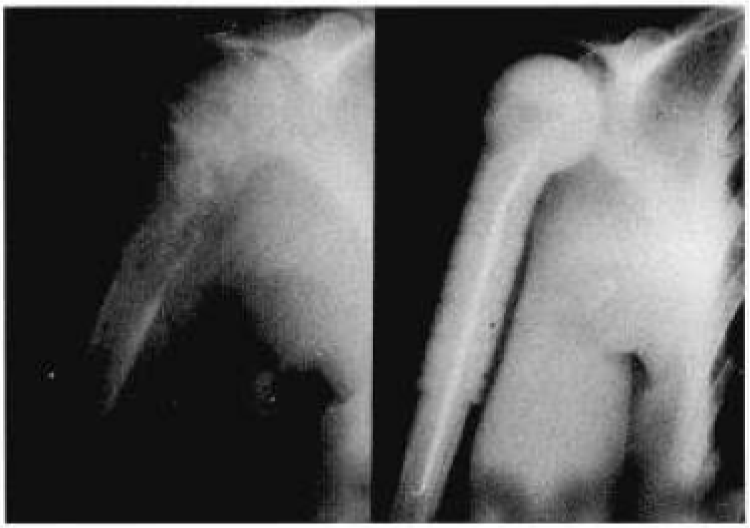

Figure 1. Preoperative anteroposterior radiograph of Ewing's sarcoma of the proximal one-third of the right humerus, and postoperative control after resection and replacement with an endoprosthesis.

Figure 2. An 11-year-old boy with Ewing's sarcoma treated with endoprosthesis for the hip joint.

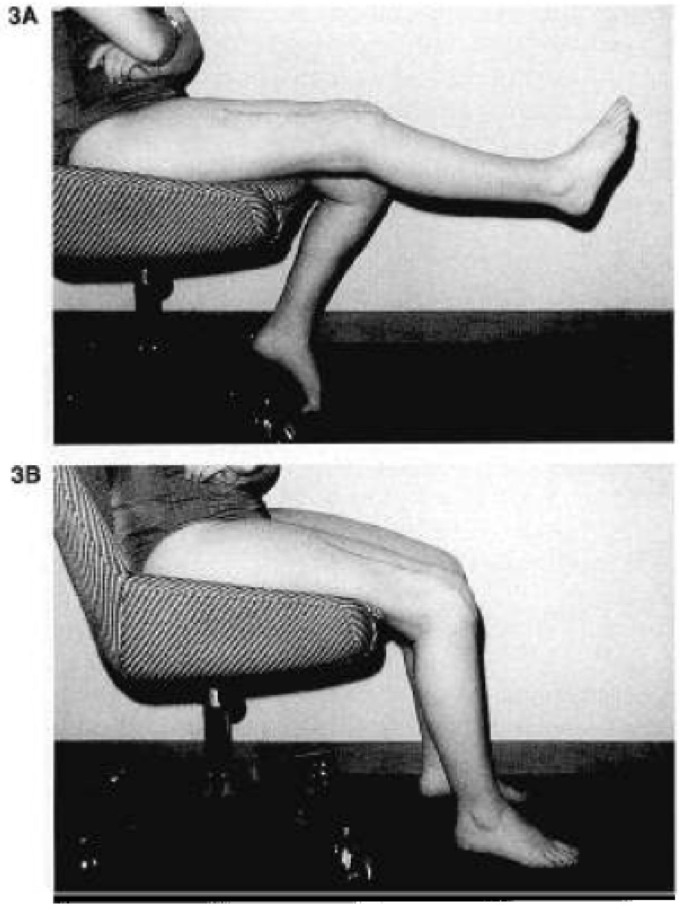

Figure 3. A and B: Functional aspect after a conservative surgery of the extremity.

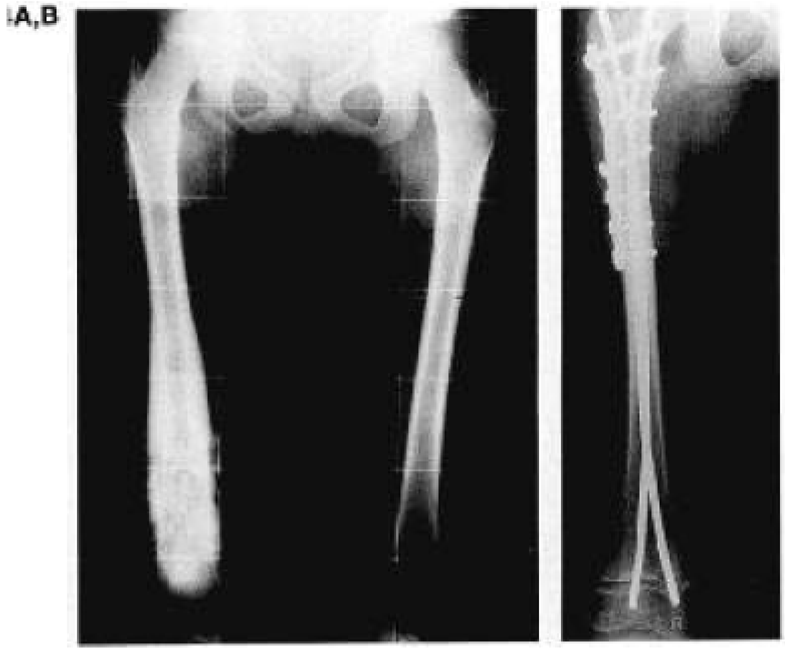

Figure 4. A 10-year-old girl affected with osteosarcoma of the distal femur **(A).** She was treated while performing physeal distraction. The segment was removed en bloc, and an intercalary bone graft was performed **(B).**

Figure 5. Roentgenogram of an 8-year-old girl affected with Ewing's sarcoma of the proximal tibia **(A).** We resected the tumor and effected reconstruction with an intercalary bone allograft **(B).**

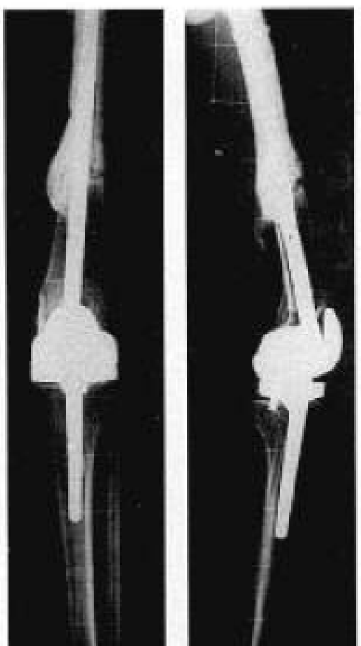

Figure 6. Osteosarcoma of the distal femur; radiological appearance after consolidation.

7A–D

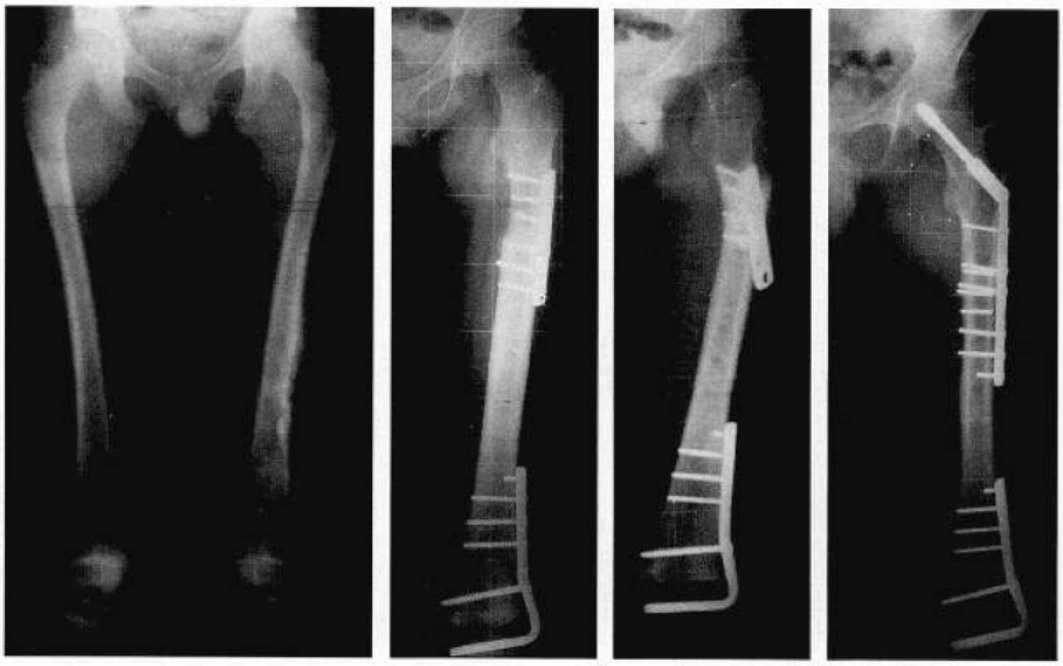

Figure 7. A: Osteosarcoma at the middle femur. **B:** Allograft replacement after tumoral en bloc resection, and fixation with a condylar plate and a DCP plate. **C:** Osteosynthesis anchorage detachment. **D:** Fixation with a DHS plate shows consolidation 6 months later.

8A–C

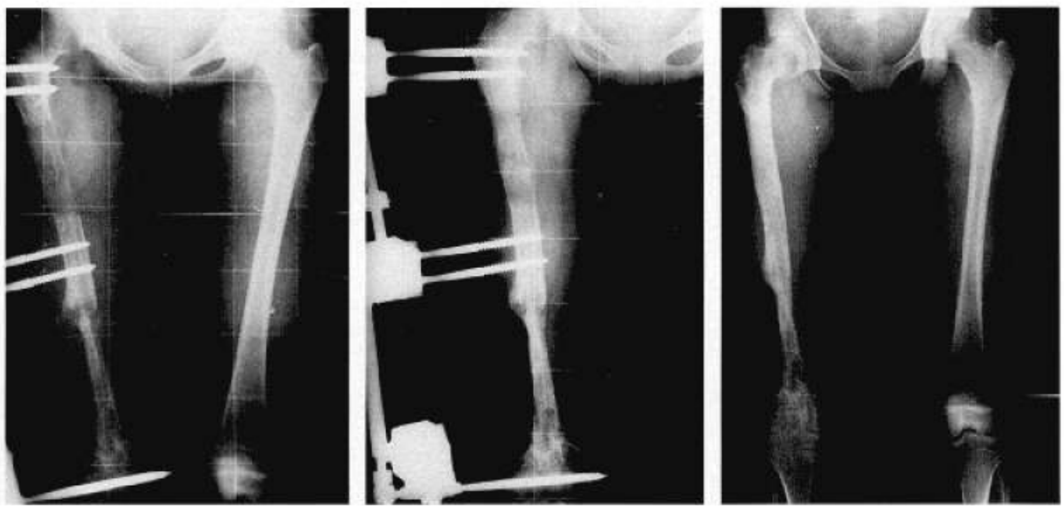

Figure 8. A and B: Radiographs taken during lengthening period show technique using an external fixation with three pin holders and a proximal metaphyseal osteotomy. **C:** Final result after lengthening.